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IMPROVING CIGARETTE YIELDS WITH EXPANDED TOBACCO

Introduction

The idea of "puffing" or "expanding" leafy or vegetable materials with a resultant decrease in density or increase in filling power is not new - although it has not always been done for the purpose of improving filling power. In 1902 a patent was granted to Anderson (1) which disclosed the puffing of rice and and wheat. The same principle was applied to tobacco in a patent granted to Hawkins (2) in 1931 using air, carbon dioxide, or steam under moderate pressure.

In 1964 a patent was issued to De Souza et al (assigned to Imperial Tobacco Company of Canada) which claimed the expansion of tobacco using volatile organic solvents (3). Since the issuance of this latter patent, a multitude of patents concerning the expansion of tobacco by various and sundry means have issued. At the present time a large number of tobacco companies have installed expansion processes. These processes have been built under the company's own patent rights or the process has been licensed from another company.

There are two primary factors which have accelerated the use of expanded tobacco: (a) the rising cost of doing business which has necessitated improved cigarette yields to maintain a satisfactory profit margin, and (b) the trend toward lower tar and nicotine cigarettes.

The following table summarizes the major patents which have issued:

Ref.No.	Year	Inventor	Patent No.	Assignee	Type Process
2	1931	Hawkins	1,789,435	AMF	Pressure & Release
4	1965	Strubel &Moll	3,223,090	B & W	Freeze Drying
5	1970	Moser et al	3,524,452	RJR	Organic Liquids
6	1972	Abbott et al	3,704,716	FMC	Freeze Drying
7	1973	Michaux et al	3,734,104	PM	Stems only; H_2O + heat
8	1973	Armstrong et al	3,771,533	PM	$(NH_4)_2CO_3$ process
9	1973	Johnson	3,710,803	Research Corp.	Freeze Drying
10	1973	Abbott et al	3,749,103	FMC	Freeze Drying
11	1973	Ashburn	3,753,440	RJR	Organic Liquids
12	1974	Johnson	3,785,385	Research Corp.	Freeze Drying
13	1974	Johnson	3,786,818	Research Corp.	Freeze Drying
14	1979	Glock	4,161,953	American Brands	Freeze Drying

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The first column in the table lists the reference numbers corresponding to references at the end of this article. It may be seen from the table that 1973 was a period of great activity in the development of expansion processes for tobacco.

General Principles of Expansion Processed

In order to understand the principle by which tobacco is expanded, it is necessary to know something about the nature of the material being expanded, in this case tobacco leaf.

A leaf of any vegetable material is composed of several layers of tissue (15): An outer layer on either side of the leaf is called the cuticle. This is follwed, on both sides, by a layer called the epidermis. The cell material between the two epidermis layers, and which make up the bulk of the leaf, is called the mesophyll. Located in the epidermal layers are small openings called stomata through which the plant "breathes".

Since the mesophyll make up the bulk of the leaf, it is necessary to increase the volume of these cells in order to achieve any significant (or commercial) degree of expansion. One means for doing this is to force a volatile organic liquid, such as freon, into these cell and then rapidly expand it through the positive application of heat. The resulting pressure built up in the cell walls causes them to expand and increases the bulk volume (filling power) of the leaf.

From the list of patents shown in the previous table, it is evident that there is more than one way to bring about expansion. Not all of these processes have been commercially successful, either because they failed to achieve sufficient expansion to justify the cost or the investment and operating costs of the process were simply too high.

One may readily detect expanded tobacco in a tobacco blend, either through photomicrographs or simply floating the tobacco in a low density solvent such as acetone. Photomicrographs show a striking difference in structure between unexpanded and expanded tobacco. Commercial expansion processes of which the writer has knowledge achieve 50-100% leaf expansion.

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Economics of Expansion Tobacco Processes

It was indicated earlier that one of the objectives in expanding tobacco is to reduce manufacturing costs. The manufacturing cost reduction which is achieved is dependent on the improvement in cigarette yield relative to the investment and operating costs. It was also previously stated that not all expansion processes described in the patent literature achieve the same degree of expansion. Furthermore a given process may, within limits, be operated to achieve various degrees of expandion by varying the operating conditions.

Figure 2 shows how cigarette yield will vary with degree of expansion of the tobacco blend component under consideration and the percent of that component in the blend. This figure was derived on the assumption that the tobacco component to be expanded has initially the same filling power as the cigarette blend with which it will ultimately be mixed. It was shown in a previous article (16) that the filling power of a blend is the sum of the filling powers of the individual constituents times their weight fraction in the blend. Therefore, Figure 2 is derived from the equation:

$$\text{Relative Yield} = \left\{1 + \frac{E}{100}\right\}\left(\frac{B}{100}\right) + \left\{1 - \frac{B}{100}\right\}$$

where: E = percent expansion; B = percent expanded tobacco in the blend. The initial blend was taken to have a filling power of unity. Since the curves of Figure 2 were calculated, they must be considered only approximate.

From Figure 2 it may be seen that with 60% expansion with a 40% usage of expanded tobacco in the blend, the relative cigarette yield is 1.24; i.e., a 24% increase in cigarette yield. Note that the same improvement in yield could be obtained through a 30% expansion and 80% usage of expanded material in the blend. The choice of which way to go is dependent on the economics and the physical and taste properties of the resulting cigarettes.

Types of Expansion Processes

There are only a few general processes represented in the table of patents given previously. Of these, still fewqer have been commercially successful: (a) the use of volatile organic liquids for impregnation followed by the use of heat for rapid expansion, (b) the use of liquefied gases under pressure and their sudden release on the positive application of heat, and (d) the ammonium carbonate process which involves the rapid decomposition of a solid impregnant with the application of heat and the rapid evolution of gases.

I have tried to depict the general flow scheme for all of these processes through the generalized schematic diagram shown in Figure 2. Referring to this Figure, the process is as follows:

Cured tobacco to be expanded is first conditioned to an appropriate moisture content, usually 11 - 13%. The tobacco then passes into an impregnator. At this point the process may be either continuous of semi-continuous. If a volatile organic liquid such as freon is used, the process may be continuous with the flow of liquid in the impregnator being generally countercurrent to the flow of tobacco. If a liquefied gas at higher pressure, such as CO_2 or ammonia is used, the process may be semi-continuous.

After the tobacco is sufficiently impregnated with the liquid or liquefied gas, it is generally suspended in a hot air stream or a mixture of hot air and steam in the "expander". A heater and a recirculating blower assure a constant supply of hot gas. The residence time of the tobacco in the expander and the temperature of expansion are two variables which can control the degree of expansion taking place. These also vary with the type of impregnant used.

After passing through the expander, the hot gases and expanded tobacco pass into a separator (usually of the cyclone type). If a valuable organic liquid has been used, it is worth recovering, so the expanded tobacco passes into a heated chamber where the residual liquid is recovered by means of a condenser. The vapors from the separator also pass through the condenser. The recovered organic liquid is returned to the impregnator.

If a liquefied gas such as CO_2 is used, the recovery system may be bypassed and the tobacco then passes directly to a reordering cylinder.

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According to the patent teaching, in the ammonium carbonate process, the tobacco is treated with ammonia gas and carbon dioxide. This forms ammonium carbonate within the tobacco tissues. Since ammonium carbonate will decompose to carbon dioxide and ammonia below the charring temperature of tobacco, expansion of the tobacco is brought about by rapid application of heat.

A number of patents have issued on the expansion of tobacco through freeze drying. To the writer's knowledge, there is no commercial process in operation using freeze drying to expand tobacco. For this purpose it has generally been rejected as being too expensive. It is well known of course that freeze drying is used extensively in the food industry for another purpose. In freeze-drying, the tobacco is brought to a high moisture content ("turgor" conditioned), the water is frozen, and then the water is sublimed from the tobacco under vacuum. This process differs significantly from the others described in that it is necessary to use a large amount of water relative to the tobacco and the tobacco is dried below room temperature. It is possibly a combination of the expanding ice crystals formed <u>in situ</u> and the rapid release of water vapor during sublimation which is responsible for the expansion which occurs.

The Future of Expanded Tobacco

There is no question that expanded tobacco is "here to stay" as long as there is a demand for cigarettes. At least three American manufacturers have developed their own processes: R.J.Reynolds, Philip Morris, and American Brands. At least two of these companies have licensing arrangements both domestically and overseas.

The more usual amount of expanded tobacco found in U.S. cigarettes is 20 - 25%. At least one brand is known to have 50 - 60% by weight expanded tobacco. Obviously the use of expanded tobacco has improved the profit picture of the cigarette companies - not only because of the improved cigarette yields but also because of the need to purchase less leaf. This latter fact will have an adverse impact upon the tobacco grower.

With the median tar and nicotine content of cigarettes seeking lower and lower levels, expanded tobacco offers the cigarette manufacture another tool for accomplishing this. Although lighter cigarettes will burn faster, this may be offset totally or partially by selecting the appropriate cigarette paper. The end result is that the manufacturer has more variables at his disposal.

No doubt the technology of expanding tobacco will continue to advance as more and more tobacco companies develop their own processes. Existing processes will also be improved in the natural course of attempting to reduce capital and operating costs.

References

(1) Anderson, U.S. Patent 707,892, August 1902.
(2) Hawkins, U.S. Patent 1,789,435, Jan.1931
(3) De Souza et al, U.S. Patent 3,144,871, August, 1964.
(4) Strubel et all, U.S. Patent 3,223,090, Dec.1965.
(5) Moser et al, U.S. Patent 3,524,452, August 1970.
(6) Abbott et al, U.S. Patent 3,704,716, December 1972.
(7) Michaux et al, U.S. Patent 3,734,104, May, 1973.
(8) Armstrong et al, U.S. Patent 3,771,533, Nov.1973.
(9) Johnson, U.S. Patent 3,710,803, Jan. 1973.
(10) Abbott et al, U.S. Patent 3,749,103, July 1973.
(11) Ashburn, U.S. Patent 3,753,440, August 1973.
(12) Johnson, U.S. Patent 3,785,385, Jan.1974.
(13) Johnson, U.S. Patent 3,786,818, Jan.1974
(14) Glock, U.S. Patent 4,161,953, July 1979.
(15) "Modern Biology" by Otto and Towle; Holt, Rinehart, and Winston, Inc. (1969).
(16) Samfield, Max; Prediction of the Filling Power of Cut Tobacco from Chemical Analysis of the Leaf, Tabak Journal International, 2/80; p.126.

FIGURE 1.

RELATIVE CIGARETTE YIELD AS A FUNCTION OF PERCENT TOBACCO EXPANSION AND PERCENT IN THE BLEND

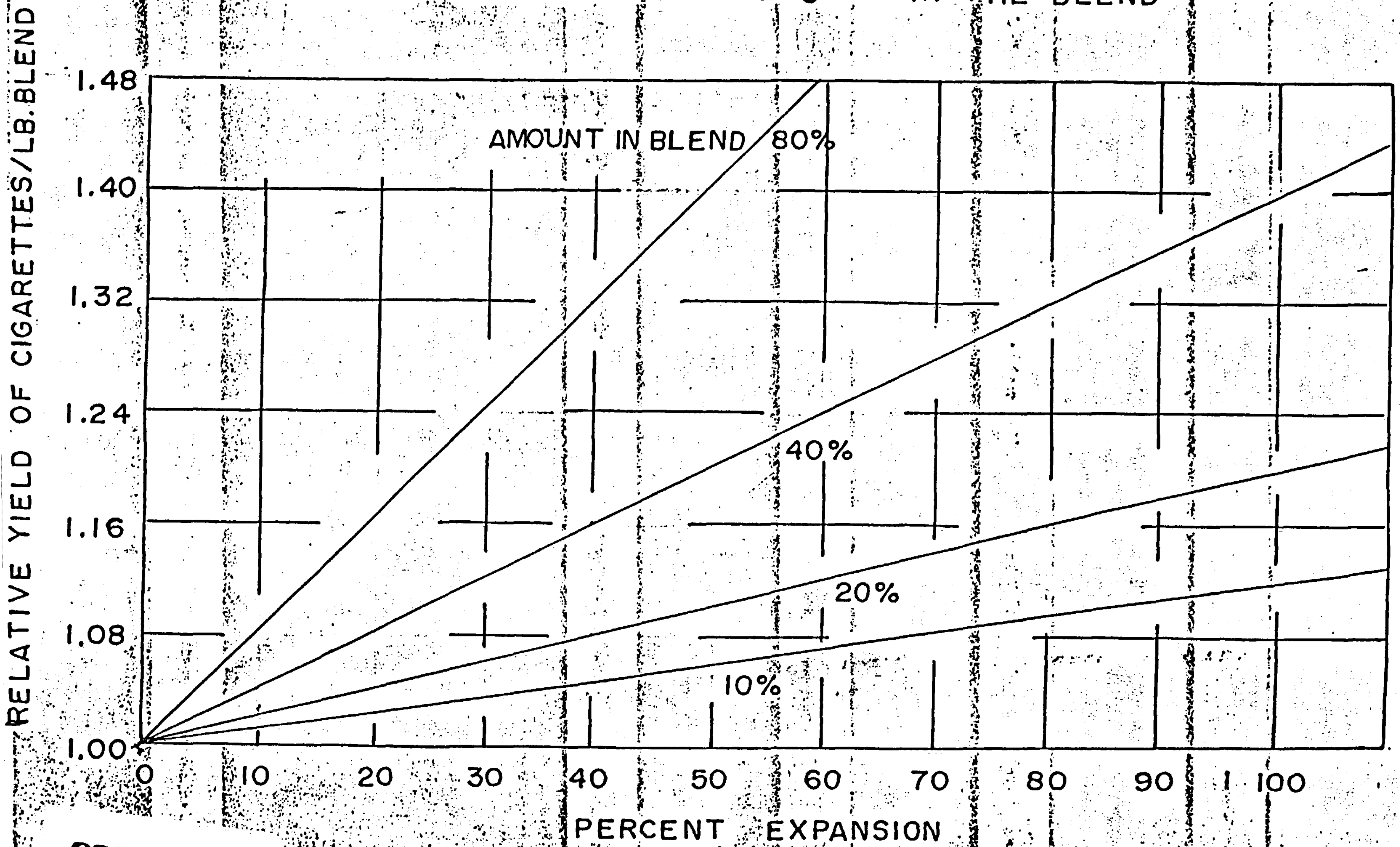

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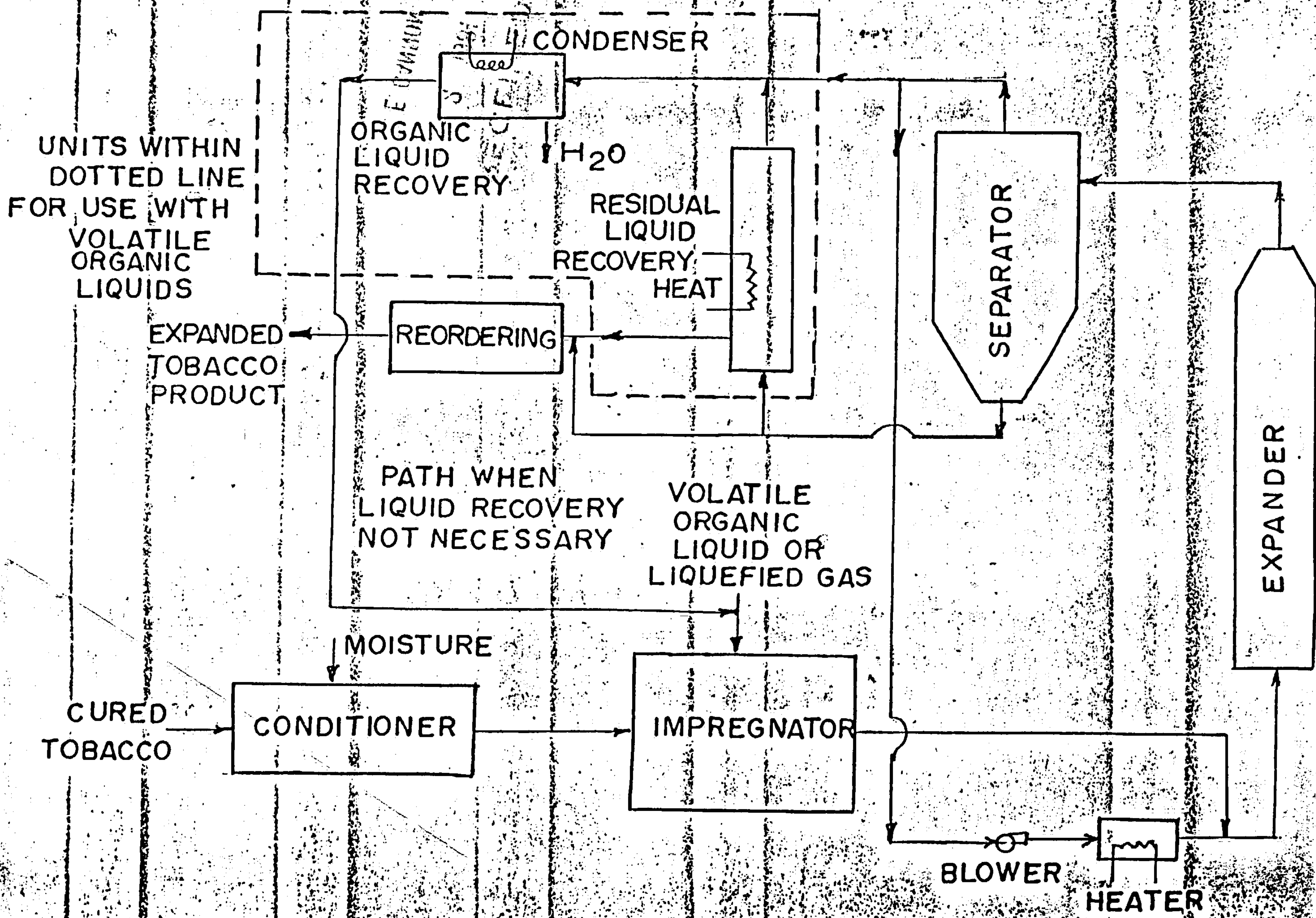
FIGURE 2.

GENERALIZED SCHEMATIC FOR MAJOR TOBACCO EXPANSION PROCESSES



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